

1994018764  
N94-22237

1993 NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

JOHN F. KENNEDY SPACE CENTER  
UNIVERSITY OF CENTRAL FLORIDA

57-45  
197193  
p-29

A PROTOTYPE EXPERT/INFORMATION SYSTEM FOR EXAMINING  
ENVIRONMENTAL RISKS OF KSC ACTIVITIES

PREPARED BY:

Dr. Bernard A. Engel

ACADEMIC RANK:

Associate Professor

UNIVERSITY AND DEPARTMENT:

Purdue University  
Department of Agricultural Engineering

NASA/KSC

DIVISION:

Biomedical Operations and Research

BRANCH:

Biological Research and Life Support

NASA COLLEAGUE:

John C. Sager

DATE:

August 6, 1993

CONTRACT NUMBER:

University of Central Florida  
NASA-NGT-60002 Supplement: 11

## Abstract

Protection of the environment and natural resources at the Kennedy Space Center (KSC) is of great concern. An expert/information system to replace the paper-based KSC Environmental Checklist was developed. The computer-based system requests information only as required and supplies assistance as needed. The most comprehensive portion of the system provides information about endangered species habitat at KSC. This module uses geographic information system (GIS) data and tools, expert rules, color graphics, computer-based video, and hypertext to provide information.

## Summary

A decision support system project has been initiated to develop software to assist with environmental and natural resource management at KSC. A module for this decision support system was developed based on the paper-based KSC Environmental Checklist. This checklist must be completed before most activities of significance can be conducted/completed at KSC. The paper-based checklist requires information and expertise that those completing the checklist often don't have.

A prototype expert/information system based on this checklist was developed. This system was developed using KnowledgePro Windows (an expert system and multimedia development tool) and PC ARC/View (a geographic information system (GIS) data display and analysis tool). The resulting system requires a PC with Microsoft Windows and PC ARC/View. The checklist was implemented such that users complete a computer-based checklist in a manner similar to completing the paper-based check list. Based on items checked, the system requests additional information only as required. Users of the system can request additional information to complete checklist items through hypertext links. The hypertext links provide a variety of information. For example, one of the checklist items asks whether endangered species habitat will be affected. Selection of this link accesses an extensive expert/information system that provides information about KSC wildlife habitat, KSC habitat locations, wildlife species, and wildlife habitat requirements. Much of the textual information in this section is based on a biodiversity publication being prepared by NASA contractor personnel. Hypertext links are used to provide access to this information. This system also makes extensive use of video clips, graphics, and GIS data.

The prototype system is in a usable form, but many additional features and capabilities should be added. With only slight modifications, the habitat and wildlife module could be used as an educational and training tool at KSC and many other locations including schools.

## TABLE OF CONTENTS

I.	INTRODUCTION
II.	RELATED LITERATURE
III.	PROCEDURES
3.1	Expert/Information System Development
3.2	GIS Data Development and Documentation
3.3	GIS Data at KSC
3.4	Expert System Development Tool
3.5	Habitat Module
3.6	Video Capture
3.7	Graphics Capture
IV.	RESULTS AND DISCUSSION
4.1	Example Screens from ARC/View
4.2	Example Screens from the Expert/Information System
V.	SUMMARY AND CONCLUSIONS
VI.	RECOMMENDATIONS FOR CONTINUED WORK
APPENDIX A	CONVERSION OF ERDAS GIS DATA FOR USE IN ARC/VIEW
APPENDIX B	CLIPS FILE FOR ADDING TEXT LABELS TO INFO TABLE FOR WETLANDS LAYER
APPENDIX C	CONVERSION OF UNIX ARC/VIEW COMPATIBLE FILES FOR USE WITH THE MS WINDOWS ARC/VIEW
APPENDIX D	STRATEGY FOR DEVELOPMENT OF ENVIRONMENTAL AND NATURAL RESOURCES DECISION SUPPORT SYSTEMS AT KSC
VII.	REFERENCES

## LIST OF ILLUSTRATIONS

Figure	Title
4.1	Portion of an ARC/View Data <i>View</i>
4.2	Data Table from an ARC/View Data <i>View</i>
4.3	Portion of the Expert System Environmental Checklist
4.4	List of KSC Habitat Types
4.5	Menu to Access Scrub Habitat Information
4.6	Species that Require and Use Scrub Habitat
4.7	Menu to Access Scrub Jay Information
4.8	Textual Scrub Jay Information

## I. INTRODUCTION

The Kennedy Space Center (KSC) is not only home to many NASA activities but it is also home to 22 wildlife species listed as Endangered or Threatened on either the Federal or State lists. When NASA purchased land for the development of KSC in the early 1960's, not all of the land was needed for the space program. As a result, the U.S. Fish and Wildlife Service in cooperation with NASA established the Merritt Island National Wildlife Refuge in 1963. Thus, the effects of NASA activities on the environment and natural resources are of great concern.

A variety of monitoring and research activities are conducted by scientists at KSC to protect the KSC environment and natural resources and to better understand the relationships between these systems and NASA operations. These activities include: water quantity and quality monitoring and modeling (Dwor-nik, 1984; Heaney et al., 1984; Bennett, 1989; Dierberg and Jones, 1989), soil resources inventory development (Schmalzer and Hinkle, 1990a and 1991), climate monitoring (Madsen et al., 1989; Dreschel et al., 1990; Mailander, 1990), wildlife monitoring (Breininger and Schmalzer, 1990; Dreschel et al., 1991), and vegetation/habitat monitoring (Breininger, 1990; Schmalzer and Hinkle, 1990b; Provan-cha and Hall, 1991).

To assist in protection of the environment and natural resources at KSC, an environmental checklist must be completed prior to construction and many activities at KSC. The KSC Environmental Checklist was recently developed for KSC along with a document to provide assistance in completion of the check-list. Several of the checklist items that must be addressed require access to databases and information that reside in various formats and at various locations at KSC. In many cases, this information is not well documented and people requiring access don't know it exists. Other questions on the checklist can be difficult to answer. Examples of such checklists can be found in KHB 8800.6.

The objective of this project was to develop a prototype expert/information system to assist with the completion of the KSC environmental checklists. It is envisioned that this system would become part of a larger environmental/natural resources decision support system that is being developed for KSC.

## II. RELATED LITERATURE

Environmental concerns and issues have and will continue to greatly shape the political agenda at local, state, and national levels. Environmental considerations have become important components of project planning as a result of the National Environmental Policy Act (NEPA) (Liroff, 1976) (Bear, 1989) and public pressures. Environmental considerations are often accounted for through environmental impact assessments.

Environmental Impact Assessment (EIA) requires the qualitative and quantitative prediction, analysis, and assessment of the impacts of human activities on the environment. A variety of methods and tools are used to perform EIAs. EIA techniques range from simple checklists and qualitative impact matrices to complex computer-based approaches that use simulation, optimization, GIS, and expert system techniques. The formats of these techniques range from narrative and qualitative descriptions to various attempts at quantification and formalization, from monetization to graphical methods. The procedures may involve experts, expert teams, panels, workshops, public hearings, and court proceedings (US EPA, 1992). The legal, procedural and institutional components of EIAs are important aspects but can vary greatly from project to project.

Some of the EIA techniques that have been successfully used include:

- Graphic overlay methods (McHarg, 1968; Dooley and Newkirk, 1976)
- USGS Matrix (Leopold et al., 1971)
- Network Analysis (Sorensen, 1971; Sorensen, 1972)
- Cross-impact Simulation (Kane, 1972)
- EES Environmental Evaluation System (Dee et al., 1973)
- HEP Habitat Evaluation Procedures (US Fish and Wildlife Service, 1976)
- Decision Analysis (Keeney and Raiffa, 1976)
- WRAM Water Resources Assessment (Solomon et al., 1977; Richardson et al., 1978)
- EQA Environmental Quality Assessment (Duke et al., 1977)
- METLAND Landscape Planning Model (Fabos et al., 1978)
- Goals Achievement Matrix (Hill, 1968)
- WES Wetland Evaluation System (Galloway, 1978)
- AEAM Adaptive Environmental Assessment (Holling, 1978)
- EQEP Environmental Quality Evaluation Procedure (Duke, 1979)
- CBA Cost-Benefit Analysis and related methods
- Mathematical modeling (Bonazountas et al., 1988; Forgensen, 1991)
- Interactive Systems Analysis and Decision Support (Fedra et al., 1987; Lein, 1989; Fedra 1991; Fedra et al., 1991)

Additional details concerning EIA techniques can be found in Clark et al. (1984), Beanlands and Duinker (1983), Tomlinson and Atkinson (1987), Bregman and Mackenthun (1992), Bisset (1988), and numerous

others.

Fedra (1992) describes several intelligent environmental information systems applications the International Institute for Applied Systems Analysis has developed. XSPILL is a dynamic analytical model to simulate the propagation of an accidental spill of a chemical in a river. XSPILL integrates GIS, a river simulation, a hypertext information system, and graphical visualization techniques. Another system uses several simulations, finite element techniques, GIS, visualization techniques, and expert systems to simulate the movement of groundwater contaminants under various scenarios. Fedra (1993) describes the expert systems that are used in the overall system in more detail. The system is used for the management of hazardous waste, site selection and risk assessment of landfills, and the design and evaluation of groundwater remediation measures.

Fedra (1991) describes a series of computer-based decision support systems to assist with environmental impact assessment. The decision support modules use expert systems, environmental assessment checklists in rule-based formats, databases, GIS, simulations, and visualization techniques. Extensive modules assess air quality, surface water quality, and groundwater quality.

Fedra et al. (1991) developed MEXSES, a rule-based expert system for environmental impact assessment at a screening level, starting at an early stage of project planning and design. MEXSES uses environmental assessment checklists in expert system form, databases, GIS, a hypertext explanation facility, and visualization techniques. The system was implemented on a UNIX workstation using X Windows. MEXSES was successfully applied to the Lower Mekong Basin of Thailand.

Negahban et al. (1993) developed a GIS-based decision support system to assist with regional environmental planning in the Lake Okeechobee, Florida basin. The primary contaminant considered by the system is phosphorus from agricultural areas of the basin. Kowalski and Bagley (1993) describe the US Army computer-based natural resources management system. Carlson et al. (1993) describe the Soil Conservation Service (SCS) computer-based systems that assist with erosion control and water quality protection. Garcia et al. (1993) developed a decision support system that uses GIS and habitat models to quantify the quality of wildlife habitat. Shih and Mills (1993) developed a spatial and ecological forest management system for upland central hardwood species of the US. Gough and Edwards-Jones (1993) developed a knowledge-based system to provide EIA training. Gurganus et al. (1993) developed a comprehensive educational/information transfer hypermedia program on environmental assessment. This program makes extensive use of graphics and hypertext.

Denno and Brail (1993) describe a decision support system that uses GIS, models, video and graphics to assist with transportation planning. Kindleberger and Meyers (1993) describe several applications in which multimedia techniques and GIS are being integrated to develop decision support systems and training systems. The Home Ownership Counseling System they developed incorporates audio, video, animation, text, and GIS data to assist potential first time home buyers.

Many of the systems and techniques described above are applicable to this project and the larger KSC environmental decision support system project.



### III. PROCEDURES

#### 3.1 Expert/Information System Development

The development of the environmental checklist expert/information system followed conventional expert system development techniques (Jones and Barrett, 1989; Waterman, 1986). The focus of the expert/information system was narrowed to the paper-based KSC Environmental Checklist. The project was further narrowed to focus on items in the checklist for which the KSC Ecological Program and the Remote Sensing and GIS Lab routinely provide information.

A conceptual design of the system was developed following discussions with those involved in the larger environmental decision support system project. It was decided to maintain the checklist format of the original KSC Environmental Checklist. Expert/information system modules would be accessed from individual items in the checklist.

Several sources of information were collected for use in the system development. Environmental checklists and environmental documents that are used at KSC were examined. Publications describing work conducted at KSC related to the environment and natural resources were reviewed. Literature describing EIA techniques and tools that are commonly used was reviewed as indicated in the Related Literature section.

The sections that follow describe the tools, information development and information collection procedures that were used. The system was developed on a 486 PC running Microsoft Windows. The system utilized expert system techniques, hypertext, GIS, computer-based video, and graphics.

#### 3.2 GIS Data Development and Documentation

Spatial data play an important role in the management of the environment and natural resources. As described earlier, spatial data stored in GIS are often used in environmental impact assessment and other systems for environmental management. Answers to several of the questions on the KSC Environmental Checklist require the use of spatial data.

For this project, ARC/View (Environmental Systems Research Institute, 1992) was selected to display and manipulate the spatial data. ARC/View is a tool for displaying, browsing, and querying geographic or spatial data. ARC/View provides several significant advantages to this project. These advantages include:

- Easy to use. ARC/View is entirely icon driven. Within a few hours, someone with no experience with GIS tools can master the capabilities of ARC/View.
- Inexpensive. The cost of ARC/View for PCs and Macs is approximately \$400 and for UNIX workstations approximately \$900.
- Runs on multiple computers. ARC/View is available for PCs running Microsoft Windows, for Macs, and for UNIX workstations.
- Personnel familiar with ARC/View. Several NASA contractor personnel have experience with ARC/View.
- Supports multiple data formats. ARC/View is able to display spatial data that have various formats including ARC/Info and ERDAS.

The disadvantages of ARC/View to this project are listed below. However, several of these disadvantages will be eliminated with the release of a new version of ARC/View in late 1993.

- Limited data analysis capabilities. ARC/View is only able to display spatial data and generate simple tables of statistics. Additional data analysis capabilities will be included in the new version of ARC/View. However, additional capabilities will mean a more complex tool and thus additional training requirements/commitments.
- No data entry/modification capabilities. Data can't be entered or modified using ARC/View. Other GIS tools must be used to modify or add data sets. The new release of ARC/View will eliminate some of this problem. However, this again increases the knowledge of ARC/View that a user must have.

Despite these limitations, ARC/View should provide the capabilities required early in the project and the KSC environmental decision support project. If additional capabilities are required, the new release of ARC/View or ARC/Info would likely be viable options.

### 3.3 GIS Data at KSC

Extensive GIS data sets have been developed for KSC by the KSC Remote Sensing and GIS Lab to support ecological and habitat research and management. The data sets identified for use in this project include:

- Vegetation types
- Habitat types
- Soils
- Wetlands
- Groundwater recharge areas
- Scrub jay habitat
- KSC boundaries

Other GIS data sets have been developed by KSC Master Planning. The data sets identified for use in this project include:

- Roads
- Buildings and parking lots
- Water lines
- Sewer and storm drains
- Power lines
- Drainage ditches
- Railroads

Numerous other GIS data layers are available from the Remote Sensing and GIS Lab and from Master Planning. Portions of the remaining data sets will be useful to future decision support system

development efforts.

The above data sets listed above served as a starting point for development of the spatial data component of the system. However, before using these data in ARC/View, additional data labeling/documentation was required. Data from the KSC Remote Sensing and GIS Lab were stored in ERDAS software formats. Although ARC/View could display these data without modification, the tabular reports of statistics aren't available for this format. Statistics are only available within ARC/View for data in ARC/Info formats. The ERDAS data were converted to the ARC/Info format as described in Appendix A (Conversion of ERDAS GIS Data for Use in ARC/View). In addition to conversion of formats, the addition of labels was required. For example, the converted soil map contained only numerical labels for areas and thus soil series names were added to the Info data tables. This process is also described in Appendix A. Data from Master Planning were used without modification.

Once data layers were modified using the procedure described above, several *views* were constructed. Within ARC/View, a view is a collection of GIS data layers and information about how to display these data and the associated tabular data. A view defines the data that is to be displayed when it is opened, the data that is available for display, the order of data layers in the display menu, data layer legends, and other information. Several views were developed to support the different components of the expert system.

### 3.4 Expert System Development Tool

Expert system development tools are usually used to facilitate the development of expert systems (Engel et al., 1991). For this project, KnowledgePro Windows (Knowledge Garden, 1991) was selected as the expert system development tool. KnowledgePro Windows supports both object-oriented and rule-based programming approaches. The reasons for its selection include:

- Preferred computer for delivery. The preferred computer for delivery of the prototype system is a PC.
- Multimedia capabilities. KnowledgePro Windows supports PC multimedia extensions and provides several multimedia capabilities. Graphics and hypertext can be easily incorporated within applications using KnowledgePro commands.
- No runtime license. KnowledgePro Windows applications do not require the purchase of a runtime license.
- Interaction with other Microsoft Windows applications. KnowledgePro Windows runs under Microsoft Windows and thus interacts well with other Windows applications including PC ARC/View.

### 3.5 Habitat Module

One of the checklist questions asks whether endangered species habitat will be affected. To answer this question, an extensive expert system module was developed. A publication on biodiversity at KSC (currently under development) served as the starting point for this module. This document contains extensive descriptions of wildlife species at KSC, habitat descriptions, and wildlife species habitat requirements.

The major sections of the habitat module include:

- Habitat descriptions
- Habitat locations at KSC
- Species use of habitats
- Species descriptions

Existing GIS data layers were reclassified to provide a GIS layer showing the habitat locations described in the biodiversity publication. Numerous wildlife and habitat graphics were added to the module. The process is described below.

### 3.6 Video Capture

Video footage of wildlife, habitat, and facilities at KSC was taken using a VHS video camera. Short video clips ranging from 3 to 10 seconds were captured and compressed for use in the expert system using Intel Smart Video Recorder hardware and software (Intel, 1993). Once captured, these video clips can be played on a PC without the video board using Microsoft Video for Windows (Microsoft, 1992). The runtime version of Microsoft Video for Windows does not require a runtime license and is easily accessed from within KnowledgePro Windows applications.

The video was captured at a 160x120 pixel resolution at between 12 and 15 frames per second. This resolution and speed was found to be the most effective option, given computer speed and file storage requirements. A compressed video clip of 75 frames (provides 5 seconds of video at 15 frames/second) required approximately 425 Kbytes of storage. This storage requirement was obtained using the compression algorithm recommended to obtain the highest quality video clips. Other compression options are available but will degrade the quality of video clips. Video for Windows is capable of uncompressing and playing compressed files at the speeds at which they were captured.

### 3.7 Graphics Capture

Slides and photographs of habitat and wildlife were captured using a scanner for the photographs and a slide digitizing device for the slides. The digitized graphics were saved in the bmp (bitmap for Windows) format. Graphics in this format were easily incorporated in KnowledgePro Windows applications.

#### IV. RESULTS AND DISCUSSION

This section describes the *views* developed for ARC/View and shows example screens from these views. The computer-based environmental checklist is also described and example screens are provided. Keep in mind however, these systems are difficult to describe because of their dynamic nature and should be viewed on the computer to be fully appreciated.

##### 4.1 Example Screens from ARC/View

Several *views* were developed in ARC/View using the GIS data layers described previously. These views can be accessed from the appropriate locations in the expert/information system or used in a stand-alone manner with ARC/View.

Figure 4.1 shows one of the views that was developed within ARC/View. The tools window (left side of the figure) allows users to query the database, measure features, find areas impacted within a given distance of a feature, and zoom within the data displayed. The center portion of the figure shows the habitat map for KSC. Using the tools menu, one can zoom to the location of interest and determine the type or types of habitat that would be affected and generate statistics of interest. The right side of the figure shows the data layers available within the view and the legend for the habitat layer. Other data layers and their legends can be displayed as desired.

Figure 4.2 shows a portion of the habitat layer from the previous figure. In this case, the user has zoomed to an area of interest and selected a map polygon. A table for the polygon is displayed showing the area, perimeter and habitat type. Other more complex tables of information are readily generated.

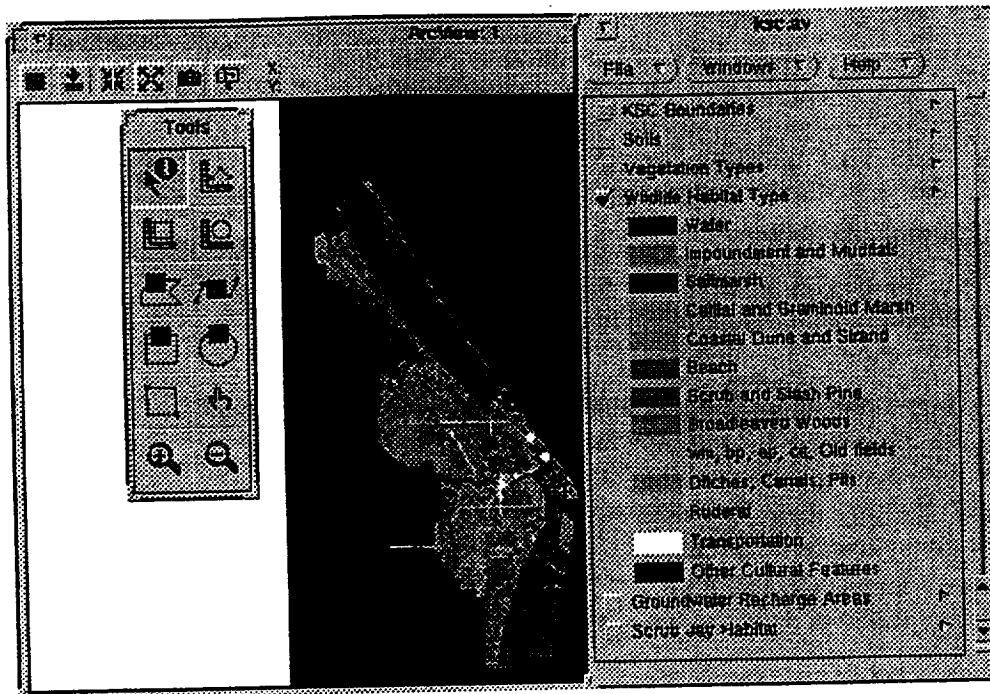


Figure 4.1 Portion of an ARC/View Data View

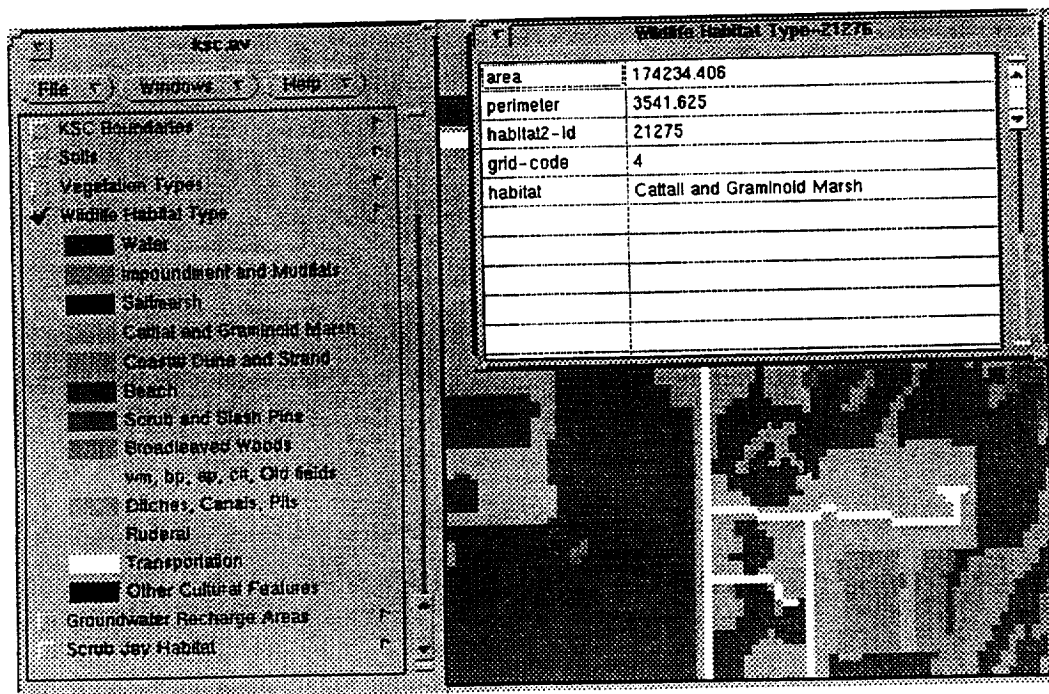


Figure 4.2 Data Table from an ARC/View Data View

## 4.2 Example Screens from the Expert/Information System

This section describes the operation of the expert/information system and provides example screens. Once the system is started, the user is asked to provide the same information as requested by the paper-based KSC Environmental Checklist. A portion of the computer-based checklist is shown in Figure 4.3. The mouse is used to check the appropriate items. Checking some items invokes questions that require additional information. For example, indicating that construction will be done in a flood plain invokes a question requesting whether the construction will be in a 100 year or 500 year floodplain.

Items within the system that are underlined are hypertext links. Selecting these items with the mouse provides additional information. For example, selecting *Construction in wetlands* provides access to a GIS layer showing wetland locations and types at KSC.

Selecting the *Endangered species habitat* link from the checklist provides access to the habitat and wildlife species expert/information system. Example screens are shown in Figures 4.4-4.8. After selecting the *Endangered species habitat* link, the user is presented a menu (Figure 4.4) requesting the type or types of habitat that will be affected. Selecting habitat types provides additional information about that habitat at KSC. Figure 4.5 shows the menu that is presented when the Scrub and Slash Pine habitat is selected from the previous menu. Figure 4.6 shows the information displayed when the *Species utilizing Scrub and Slash Pine* link is selected from Figure 4.5. This table lists the species that use this habitat and describe how they use it. Each of the species is linked to additional information about that species as shown in Figure 4.7 for scrub jays. Figure 4.8 shows a portion of the additional textual information available about scrub jays. The system user is returned one level (window) at a time after accessing additional information to allow additional links to be explored.

Does the construction, installation, removal, activation, or operation of the proposed project involve: (Fill out one page for each alternative considered; See instructions, when in doubt, check yes)

Alternative number and description:

<input type="radio"/> YES	<input type="radio"/> NO	Discharge of any substance to the environment
<input type="radio"/> YES	<input type="radio"/> NO	Land alteration, excavation, dewatering or removal of vegetation
<input type="radio"/> YES	<input type="radio"/> NO	<u>Construction in wetlands</u>
<input type="radio"/> YES	<input type="radio"/> NO	Construction in floodplain
<input type="radio"/> YES	<input type="radio"/> NO	Generation of ionizing or non-ionizing radiation or use of any radiation source
<input type="radio"/> YES	<input type="radio"/> NO	Asbestos-containing materials or facilities
<input type="radio"/> YES	<input type="radio"/> NO	PCB-contaminated materials or equipment
<input type="radio"/> YES	<input type="radio"/> NO	Generation of waste other than normal construction wastes
<input type="radio"/> YES	<input type="radio"/> NO	Use or storage of Hazardous or Toxic Materials
<input type="radio"/> YES	<input type="radio"/> NO	Aboveground or underground storage tanks
<input type="radio"/> YES	<input type="radio"/> NO	

Figure 4.3 Portion of the Expert System Environmental Checklist

What types of habitat are found within the area of interest?

- ☐ Estuarine Waters and Edge
- ☐ Impounded Open Water and Mud Flats
- ☐ Salt Marsh
- ☐ Cattail and Graminoid Marshes
- ☐ Coastal Dune and Strand
- ☐ Ocean Beach
- ☐ Scrub and Slash Pine
- ☐ Broadleaved Forests
- ☐ Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)
- ☐ Islands
- ☐ Ditches and Canals
- ☐ Ruderal Grass
- ☐ Continue

Figure 4.4 List of KSC Habitat Types



What type of additional information would you like?

- ☐ Description of Scrub and Slash Pine habitat
- ☐ Species that utilize Scrub and Slash Pine
- ☐ Location on John F. Kennedy Space Center
- ☐ Pictures of Scrub and Slash Pine habitat
- ☐ Video of Scrub and Slash Pine habitat
- ☐ Continue

Figure 4.5 Menu to Access Scrub Habitat Information

Scrub and Slash Pine Species	
The total number of priority taxon requiring this habitat is 15. The total number of priority taxon using this habitat is 30.	
Habitat Use	
<u>Florida Scrub Jay</u>	4
<u>Southern Bald Eagle</u>	B4F1
<u>Southeastern Beach Mouse</u>	2R
<u>Eastern Indigo Snake</u>	4
<u>Florida Pine Snake</u>	4
<u>E. Diamondback Rattlesnake</u>	4
<u>Arctic Peregrine Falcon</u>	F1
<u>Gopher Tortoise</u>	4
<u>Gull-billed Tern</u>	F1
<u>Bobcat</u>	4
<u>Kingsnake</u>	1
<u>Osprey</u>	B4
<u>Barn Owl</u>	F2
<u>Pileated Woodpecker</u>	3
<u>Eastern Coachwhip</u>	4
<u>Red-shouldered Hawk</u>	F2
<u>Cooper's Hawk</u>	3
<u>Northern Harrier</u>	F2
<u>Barred Owl</u>	F2
<u>Florida Mouse</u>	4
<u>Merlin</u>	F3
<u>Dusky Pigmy Rattlesnake</u>	4

Figure 4.6 Species that Require and Use Scrub Habitat

What type of additional Florida Scrub Jay information would you like?

- ☐ Seasonal abundance, population size, and measures of endangerment
- ☐ Protected status on John F. Kennedy Space Center
- ☐ Habitat location on John F. Kennedy Space Center
- ☐ Pictures of scrub habitat
- ☐ Video of scrub
- ☐ Picture of a Florida Scrub Jay
- ☐ Video of a Florida Scrub Jay
- ☐ General information
- ☐ Continue

Figure 4.7 Menu to Access Scrub Jay Information

**Florida Scrub Jay Information**

**Florida Scrub Jay** (*Aphelocoma coerulescens coerulescens*)

The Florida Scrub Jay is referred to as a disjunct race of Scrub Jay which is widespread in the western U.S. and Mexico. Recent genetic studies have shown that the Florida Scrub Jay has become distinct enough to be considered a separate species and it should be officially recognized as such within the near future (J. Fitzpatrick and D. MacDonald, pers. comm.). Its population has declined by at least 50% due to habitat loss and degradation (Cox 1987) and many remaining populations are vulnerable due to low population size, habitat fragmentation, and degradation (Fitzpatrick et al. 1991).

The Florida Scrub Jay diet consists mainly of insects and small vertebrates throughout most of the year. Acorns are extremely important in winter when insect numbers are low. Nesting season ranges from late February to early June. Reproductive success varies from one year to the next at Archbold Biological Station in Highlands County (Woolfenden and Fitzpatrick 1984) and on KSC (Breininger and Smith unpublished data). Unlike the western Scrub Jay, the

Figure 4.8 Textual Scrub Jay Information

## V. SUMMARY AND CONCLUSIONS

A decision support system project has been initiated to develop software to assist with environmental and natural resource management at KSC. A module for this decision support system was developed based on the paper-based KSC Environmental Checklist. This checklist must be completed before most activities of significance can be conducted/completed at KSC. The paper-based checklist requires information and expertise that those completing the checklist often don't have and can't easily obtain.

A prototype expert/information system based on this checklist was developed. This system was developed using KnowledgePro Windows (an expert system and multimedia development tool) and PC ARC/View (a geographic information system (GIS) data display and analysis tool). The resulting system requires a PC with Microsoft Windows and PC ARC/View. The checklist was implemented such that users complete a computer-based checklist in a manner similar to completing the paper-based check list. Based on items checked, the system requests additional information only as required. Users of the system can request additional information to complete checklist items through hypertext links. The hypertext links provide a variety of information. For example, one of the checklist items asks whether endangered species habitat will be affected. Selection of this link accesses an extensive expert/information system that provides information about KSC wildlife habitat, KSC habitat locations, wildlife species, and wildlife habitat requirements. Much of the textual information in this section is based on a biodiversity publication being prepared by NASA contractor personnel. Hypertext links are used to provide access to this information. This system also makes extensive use of video clips, graphics, and GIS data.

The prototype system is in a usable form, but many additional features and capabilities should be added. Suggestions for further development are included in the next section. With only slight modifications, the habitat and wildlife module could be used as an educational and training tool at KSC and many other locations including schools.

## VI. RECOMMENDATIONS FOR CONTINUED WORK

This section describes areas of continued and future work. Suggestions for continued work on the KSC environmental and natural resources decision support system are given in Appendix D.

The expert system developed in this project is by no means complete. Several improvements to the habitat module should be made. Additional graphics and video of wildlife and habitat should be added. Graphics of habitat at various stages of development and for the different seasons of the year should be added. Additional hypertext links within the program should be added. Further testing of current links should also be conducted. At the present time, the GIS data is not linked to the expert system because the computer used for development did not have enough RAM to allow both KnowledgePro Windows and ARC/View to run concurrently. The habitat module could be slightly modified and used for educational purposes at KSC, schools, the Fish and Wildlife Service, the National Park Service, and other special interest groups.

The GIS data for ARC/View should be subdivided based on KSC regions. The time required to display the current data layers for all of KSC on the computer used for development (33 MHz 486 with 4 Mbytes RAM) is very slow. The habitat layer with slightly over 23,000 polygons requires approximately 16.5 minutes to be entirely displayed. The scrub jay habitat with approximately 7,800 polygons requires just over 4 minutes for display. Dividing KSC into areas and subdividing the GIS data based on these regions would improve the display time to an acceptable level. The appropriate regions could be accessed through a menu or graphically using a map of KSC.

Additional GIS data layers for ARC/View must be converted for use on the PC. Disk space available on the PC was not adequate to move all of the data desired. Appendix C provides instructions for conversion of the data layers.

Additional expert system modules could be developed and added to the checklist to assist with items not addressed in the current system. Other GIS data layers would be useful in answering some of the checklist items. For example, one of the questions asks whether the proposed action will be in the 100 or 500 year flood plains. Only paper copies of these maps are available at the present time.

Other environmental checklists are used at KSC for certain activities. These checklists could also be implemented as expert systems. Other expert system modules could be developed based on questions/problems encountered by KSC pollution officers. Development of these expert systems will also require additional GIS data layers.

Opportunities exist to develop more comprehensive decision support tools for KSC such as those described in the Related Literature section. Such tools would help with day-to-day operations and long term planning.

## APPENDIX A. CONVERSION OF ERDAS GIS DATA FOR USE IN ARC/VIEW

ERDAS GIS files can be used directly by ARC/View. However, when used in this way, the data is treated as an image and thus statistics are not available within ARC/View. If statistics from ERDAS files are desired within ARC/View, a conversion process must be followed. If labeling of areas is desired, include the steps below that will allow labeling of polygons (steps 3-9). The necessary steps are described below.

1. Use ARC/Info to convert ERDAS data to ARC GRID format (erdasgrid <in\_erdas\_file> <out\_grid>).
2. Use ARC/Info to convert the ARC GRID format to the ARC POLY format (gridpoly <in\_grid> <out\_cover>). This step is necessary since the statistics desired within ARC/View can't be obtained from GRID data.
3. Within Info, select the Info file that contains the appropriate GIS layer statistics (SEL <info\_file>). The GIS layer files that must be modified are those that end with .PAT.
4. Export the information in selected file to an ascii file (EXPORT <filename> ASCII).
5. Cancel the association between the Info file and any external files (EXTERNAL)
6. Remove the data from the Info file (PURGE).
7. Modify the template of the Info file to include a new column or columns that will contain the labels that will be added (MODIFY). MODIFY is used to interactively add a column or columns. Do not remove existing columns.
8. An additional column or columns of data can be added to the file that was exported. A simple CLIPS program was used to add a column containing labels that described numeric polygon labels. The CLIPS code used for the wetlands data is provided in Appendix B (CLIPS File for Adding Text Labels to Info Table for Wetlands Layer). Other techniques could also be used to add labels. For example, soil series names were added as labels when developing the soils layer.
9. Import the external file into the modified template (IMPORT <ascii\_file\_name> ASCII).
10. The resulting information can now be accessed by ARC/View and the labels added will be displayed in ARC/View tables.

## APPENDIX B. CLIPS FILE FOR ADDING TEXT LABELS TO INFO TABLE FOR WETLANDS LAYER

```
(defrule xx
  (declare (salience 5))
  (initial-fact)
  =>
  (open "wetlands.exp" ex.file "r") ;; open the exported wetlands data file
  (open "wet" ex2 "w")           ;; open a file to write new data in
)
```

```
(defrule xx2
  ;; read original data and determine text label to add - then add new label
  (initial-fact)
  =>
  (bind ?c 1)
  (bind ?c2 0)
  (while (< ?c2 24000)
    (while (< ?c 6)
      (bind ?x (read ex.file))
      (bind ?c (+ ?c 1))
      (fprintout ex2 ?x crlf)
    )
    (readline ex.file)
    (if (= ?x 1) then (fprintout ex2 "
  (if (= ?x 2) then (fprintout ex2 "
  (if (= ?x 3) then (fprintout ex2 "
  (if (= ?x 4) then (fprintout ex2 "
  (if (= ?x 5) then (fprintout ex2 "
  (if (= ?x 6) then (fprintout ex2 "
  (if (= ?x 7) then (fprintout ex2 "
  (if (= ?x 8) then (fprintout ex2 "
  (if (= ?x 9) then (fprintout ex2 "
  (if (= ?x 10) then (fprintout ex2 "
  (if (or (< ?x 1) (> ?x 10)) then (fprintout ex2 "
  (fprintout ex2 crlf)
  (bind ?c 1)
  (bind ?c2 (+ ?c2 1))
  )
)
```

## APPENDIX C. CONVERSION OF UNIX ARC/VIEW COMPATIBLE FILES FOR USE WITH THE MS WINDOWS ARC/VIEW

Before files that are used with the UNIX ARC/View can be used with the MS Windows version of ARC/View, these files must be converted. The conversion process is described below.

1. A file called `pcname.c` is installed with ARC/View during the installation of the MS Windows version of ARC/View. This file must be moved to a machine running UNIX and compiled. The executable file that is produced should be called `pcname`.
2. A UNIX shellscript file called `pcwksp` is also installed during the installation of the MS Windows version of ARC/View. This file should also be moved to a machine running UNIX. It may be necessary to modify the shell script to include the path to the `pcname` executable file that was created in the previous step.
3. Use `pcwksp` to create a PC workspace from the UNIX workspace of GIS files (`pcwksp unix_workspace pc_workspace`).
4. Copy the PC workspace created in the previous step to the PC with the MS Windows version of ARC/View. Once copied, the MS Windows version of ARC/View should access the data in a manner similar to ARC/View on UNIX. The speed at which MS Windows ARC/View displays coverages may be significantly slower than under UNIX, especially with files containing large numbers of polygons.

## APPENDIX D. STRATEGY FOR DEVELOPMENT OF ENVIRONMENTAL AND NATURAL RESOURCES DECISION SUPPORT SYSTEMS AT KSC

1. Identity potential users of the decision support system.
2. Provide key spatial (GIS) data layers to a small group (5 or 6) potential users.

ARC/View should be used to provide access to the GIS data. ARC/View is a tool for viewing GIS data. It also provides minimal data manipulation capabilities.

The strengths of ARC/View include: 1) very easy to use - minimal training of those using it would be required (probably 2 one hour sessions); 2) cost - ARC/View for a PC is less than \$500; 3) NASA contractor personnel are familiar with ARC/View; 4) runs on several machines (PCs under Microsoft Windows, Macs, and UNIX machines)

Data layers that will be provided initially must be identified. These will likely include: soils, wetlands, vegetation, habitat, facilities, and roads. For this limited number of data layers, existing computer hard disks may be of suitable size. Additional hard disk space may be required or the data layers could be placed on CD ROMs.

Involving potential users of software at the initiation of a project is almost always a good idea. Involvement will increase their support for the project and acceptance of the final product.

3. Work with potential users of the decision support system to identify their needs and questions they must answer that require the use of spatial and other environmental and natural resource data.

Providing ARC/View and some GIS data layers to potential users (see above) will provide an opportunity to better determine what capabilities the decision support systems should have.

4. Once user needs are identified, decision support system modules can be identified to fit the needs of the users. Software modules can also be prioritized for development at this point.

The additional data (both GIS and non-spatial) that will be required must also be identified. The potential users can also assist with identification of additional data requirements.

5. Develop decision support system modules. Prototypes can be quickly delivered to potential users to gain feedback.
6. Provide final versions of decision support system modules to potential users.
7. Maintain and develop new databases.
8. Maintain software modules.



## VII. REFERENCES

- Beanlands, G. E. and P. N. Duinker. 1983. An Ecological Framework for Environmental Impact Assessment in Canada. Institute for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia.
- Bear, D. 1989. NEPA at 19: a primer on an "old" law with solutions to new problems. *Environmental Law Reporter* 19 ERL 10060-10069.
- Bennett, D.B. 1989. Water Resources Analysis of a Multiobjective Drainage Network in the Indian River Lagoon Basin. Water Resources Research Center Publication No. 108. University of Florida, Gainesville, FL. 154p.
- Bisset, R. 1988. Developments in EIA methods. In: *Environmental Impact Assessment, Theory and Practice* (ed. P. Wathern). Unwin Hyman, Boston. 332 p.
- Bonazountas, M., A. Brecker, and R. G. Vranka. 1988. Mathematical environmental fate modeling. Ch. 5. In: I. Bodek, W. J. Lyman, W. F. Reehl and D. H. Rosenblatt (eds.), *Environmental Inorganic Chemistry*, Pergamon Press, New York.
- Bregman, J. I., and K. M. Mackenthun. 1992. *Environmental Impact Statements*. Lewis Publishers, Inc. Chelsea, Michigan 48118. 279 p.
- Breining, D.R. 1990. Avifauna of hammocks and swamps on John F. Kennedy Space Center. *Florida Field Naturalist* 18:21-44.
- Breining, D.R. and P.A. Schmalzer. 1990. Effects of fire and disturbance on plants and birds in a Florida oak/palmetto scrub community. *American Midland Naturalist* 123:64-74.
- Carlson, J.R., S.L. Ekblad, L.P. Aydelott, and P.E. Fuglestad. 1993. The conservation planning application system of the soil conservation system. In: *Application of Advanced Information Technologies: Effective Management of Natural Resources*. ASAE Publication 04-93. pp. 24-33.
- Clark, B.D., A. Gilad, R. Bisset, and P. Tomlinson. 1984. *Perspectives on Environmental Impact Assessment*. Reidel, Dordrecht, Netherlands.
- Dee, N. 1973. Environmental Evaluation for Water Resource Planning. *Water Resources Research* 9:523-535.
- Denno, N. and R.K. Brail. 1993. Decision support systems offer organizational efficiency for transportation planning. *GIS World*. June 1993. pp. 40-45.
- Dierberg, F.E. and K.L. Jones. 1989. Assessment of stormwater runoff for recycle in cooling towers at KSC, Florida. *Water Resources Bulletin* 25(1):43-47.

Dooley, J.E. and Newkirk, R.W. 1976. Corridor Selection Method to Minimize the Impact of an Electrical Transmission Line. James F. McLaren Ltd. Toronto.

Dreschel, T.W., B.C. Madsen, L.A. Maull, C.R. Hinkle, and W.M. Knott, III. 1990. Precipitation chemistry: Atmospheric loading to the surface waters of the Indian River Lagoon basin by rainfall. *Florida Scientist* 53(3):184-188.

Dreschel, T.W., R.B. Smith, and D.R. Breininger. 1991. Florida scrub jay mortality on roadsides. *Florida Field Naturalist* 18:82-83.

Duke, K.M. 1977. Environmental Quality Assessment in Multiobjective Planning. Batelle Columbus Laboratories. Columbus, Ohio.

Duke, K.M. 1979. Environmental Quality Evaluation Procedure Implementing Principles and Standards for Planning Water Resources Programs. US Water Resources Council. Washington, DC.

Dwornik, D.S. 1984. A Stormwater Collection and Reuse System for the Kennedy Space Center, Florida. Water Resources Research Center Publication No. 83. University of Florida, Gainesville, FL. 197p.

Engel, B.A., D.D. Jones, J.R. Wright, and S. Benabdallah. 1991. Selection of an expert system development tool. *AI Applications in Natural Resources*. 5(1):15-22.

Environmental Systems Research Institute. 1992. ArcView User's Guide. ESRI, Redlands, CA.

Fabos, J.G. 1978. The METLAND Landscaping Planning Process: Composite Landscape Assessment, Alternative Plan Formulation and Plan Evaluation. Part 3 of the Metropolitan Landscape Planning Model. Research Bulletin No. 653. University of Massachusetts Agricultural Experiment Station. Amherst, Massachusetts.

Fedra, K., M. Karhu, T. Rys, M. Skoc, M. Zebrowski, and W. Ziembla. 1987. Model-based Decision Support for Industry-Environmental Interactions: A Pesticide Industry Example. WP 87-97. International Institute for Applied Systems Analysis. Laxenburg, Austria.

Fedra, K. 1991. A computer-based approach to environmental impact assessment. In: A.G. Colombo and G. Premazzi (eds.). *Proceedings of the Workshop on Indicators and Indices for Environmental Impact Assessment and Risk Analysis*. pp. 11-40.

Fedra, K., L. Winkelbauer, and V.R. Pantulu. 1991. Expert systems for environmental screening: An application in the lower Mekong basin. International Institute for Applied Systems Analysis, RR-91-19. Laxenburg, Austria. 169p.

Fedra, K. 1992. Intelligent environmental information systems. *Vortrage Wasserbau-Symposium Wintersemester 1991/92 "Okologie und Umweltverträglichkeit"*. pp. 289-311.

- Fedra, K. 1993. Expert systems in water resources simulation and optimization. In: J.B. Marco et al. (eds.). *Stochastic Hydrology and its Use in Water Resources Systems Simulation and Optimization*. Kluwer Academic Publishers. The Netherlands. pp. 397-412.
- Galloway, C.E. 1978. *Assessing Man's Impact on Wetlands*. Report No. 78-136. University of North Carolina Water Resources Research Institute. Raleigh, North Carolina.
- Garcia, L.A., M. Armbruster, K. Buehler, and G. Williams. 1993. Spatially based decision support system developed for evaluation of wildlife habitat. In: *Application of Advanced Information Technologies: Effective Management of Natural Resources*. ASAE Publication 04-93. pp. 98-105.
- Gough, M. and G. Edwards-Jones. 1993. A knowledge management system for training planners to be aware of the environmental consequences of development projects. In: *Application of Advanced Information Technologies: Effective Management of Natural Resources*. ASAE Publication 04-93. pp. 342-350.
- Gurganus, J., M. Pearson, B.A. Engel, and D.D. Jones. 1993. *Environmental Assessment Resource Guide*. Agricultural Engineering Department, Purdue University, W. Lafayette, IN.
- Heaney, J.P., B. Koopman, D.S. Dwornik, and D.R. Saliwanchik. 1984. *Water Resources of the Kennedy Space Center*. Water Resources Research Center Publication No. 82. University of Florida, Gainesville, FL. 259p.
- Hill, M.A. 1968. A Goals-Achievement Matrix for Evaluating Alternative Plans. *Journal of the American Institute of Planners* 34:19-28.
- Holling, C.S. 1978. *Adaptive Environmental Assessment and Management*. Wiley, Chichester. 377p.
- Intel. 1993. *Intel Smart Video Recorder Installation Guide and Video Tips*. Intel Corporation, Hillsboro, OR.
- Jones, D.D. and J.R. Barrett. 1989. Building expert systems. In: *Knowledge Engineering in Agriculture*, J.R. Barrett and D.D. Jones (Eds.), ASAE Monograph No. 8, ASAE, St. Joseph, MI. pp. 21-31.
- Jorgensen, S. E. 1991. Environmental management modelling. In: *Introduction to Environmental Management* (eds., P. E. Hansen and S. E. Jorgensen). Elsevier, New York. 403 p.
- Kane, J. 1972. A Primer for a New Cross-Impact Language -KSIM. *Tech. Forecasting Soc. Change*. 4:129-142.
- Keeney, R.L. and II. Raiffa. 1976. *Decisions with Multiple Objectives: Preferences and Values Tradeoffs*. Wiley, New York, NY.
- Kindleberger, C.P. and T. Meyers. 1993. Local governments tap affordable multimedia

applications. GIS World. June 1993. pp. 46-50.

Knowledge Garden. 1991. KnowledgePro Windows User Manual. Knowledge Garden, Setauket, NY.

Kowalski, D.G. and C.F. Bagley. 1993. United States army natural resources information management. In: Application of Advanced Information Technologies: Effective Management of Natural Resources. ASAE Publication 04-93. pp. 1-8.

Lein, J. 1989. An expert system approach to environmental impact assessment. International Journal of Environmental Studies, 33:13-27.

Leopold, L.B., F.E. Clarke, B.B. Hanshaw, and J.R. Balsley. 1971. A Procedure for Evaluating Environmental Impact. US Geological Survey Circular 645. US Government Printing Office. Washington, DC.

Liroff, R.A. 1976. A National Policy for the Environment. NEPA and its Aftermath. Indiana University Press. Bloomington, Indiana. 273p.

Madsen, B.C., T.W. Dreschel, and C.R. Hinkle. 1989. Characterization and evaluation of acid rain in Central Florida from 1978 to 1987 - Ten year summary report. NASA Technical Memorandum TM 102149. Kennedy Space Center, FL.

Mailander, J.L. 1990. Climate of the Kennedy Space Center and vicinity. NASA Technical Memorandum 103498. Kennedy Space Center, FL. 62p.

McHarg, I. 1968. A Comprehensive Highway Route-Selection Method. Highway Research Record No. 246. Highway Research Board, Washington, DC.

Microsoft. 1992. Microsoft Video for Windows User's Guide. Microsoft Corporation.

Negahban, B., C. Fonyo, W. Boggess, J. Jones, K. Campbell, G. Kiker, E. Hamouda, E. Flaig, and H. Lal. 1993. A GIS-based decision support system for regional environmental planning. In: Application of Advanced Information Technologies: Effective Management of Natural Resources. ASAE Publication 04-93. pp. 169-178.

Provancha, J.A. and C.R. Hall. 1991. Observations of associations of sea grass beds and manatees in East Central Florida. Florida Scientist 54:87-98.

Richardson, S.E., W.J. Hansen, R.C. Solomon, and J.C. Jones. 1978. Preliminary Field Test of the Water Resources Assessment Methodology (WRAM): Tensas River, Louisiana. Paper No. Y-78-1. US Army Corps of Engineers. Vicksburg, Mississippi.

Schmalzer, P.A. and C.R. Hinkle. 1990a. Geology, geohydrology and soils of Kennedy Space Center: A review. NASA Technical Memorandum 103813. Kennedy Space Center, FL. 46p.

- Schmalzer, P.A. and C.R. Hinkle. 1990b. Flora and threatened and endangered plants of John F. Kennedy Space Center, Florida. NASA Technical Memorandum 102791. Kennedy Space Center, FL. 68p.
- Schmalzer, P.A. and C.R. Hinkle. 1991. Dynamics of vegetation and soils of oak/saw palmetto scrub after fire: Observation from permanent transects. NASA Technical Memorandum 103817. Kennedy Space Center, FL. 149p.
- Shih, T. and W.L. Mills, Jr. 1993. FMDSS: A spatial and ecological forest management tool for upland hardwoods of the central United States. In: Application of Advanced Information Technologies: Effective Management of Natural Resources. ASAE Publication 04-93. pp. 199-193.
- Solomon, R.C, B.K. Colbert, W.J. Hansen, S.E. Richardson, L. Canter, and E.C. Vlachos. 1977. Water Resources Assessment Methodology (WRAM) - Impact Assessment and Alternative Evaluation. Technical Report No. Y-77-1. US Army Corps of Engineers. Vicksburg, Mississippi.
- Sorensen, J.C. 1971. A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone. Dept. of Landscape Architecture, University of California at Berkeley.
- Sorensen, J.C. 1972. Some Procedures and Programs for Environmental Impact Assessment. In: R. B. Ditton and T.L. Goodale (eds.). Environmental Impact Analysis: Philosophy and Methods. University of Wisconsin Sea Grant Program. Madison, Wisconsin. pp. 97-106.
- Tomlinson, P., and S. F. Atkinson. 1987. Environmental audits: A literature review. Environmental Monitoring and Assessment 8: 239-261.
- U.S. Environmental Protection Agency. 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001.
- US Fish and Wildlife Service. 1976. Habitat Evaluation Procedures. US Fish and Wildlife Service. Department of the Interior. Washington, DC.
- Waterman, D. 1986. A guide to expert systems. Addison-Wesley Publishing Co., Reading, MA, 419p.

